

PATENT COOPERATION TREATY

REC'D 30 MAR 2006

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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

CORRECTED
VERSION

Applicant's or agent's file reference 731145	FOR FURTHER ACTION See Form PCT/IPEA/416	
International application No. PCT/DK2004/000790	International filing date (day/month/year) 17.11.2004	Priority date (day/month/year) 19.11.2003
International Patent Classification (IPC) or national classification and IPC INV. B28B3/24 B28B7/46 B30B9/06 D21J3/04		
Applicant 3H INVENTORS APS		
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 7 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input type="checkbox"/> <i>(sent to the applicant and to the International Bureau)</i> a total of sheets, as follows:</p> <ul style="list-style-type: none"> <input type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions). <input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box. <p>b. <input type="checkbox"/> <i>(sent to the International Bureau only)</i> a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>		
<p>4. This report contains indications relating to the following items:</p> <ul style="list-style-type: none"> <input checked="" type="checkbox"/> Box No. I Basis of the report <input type="checkbox"/> Box No. II Priority <input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability <input type="checkbox"/> Box No. IV Lack of unity of invention <input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement <input type="checkbox"/> Box No. VI Certain documents cited <input checked="" type="checkbox"/> Box No. VII Certain defects in the international application <input checked="" type="checkbox"/> Box No. VIII Certain observations on the international application 		
Date of submission of the demand 14.09.2005	Date of completion of this report 30.03.2006	
Name and mailing address of the International preliminary examining authority:  European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized officer Orij, J Telephone No. +31 70 340-4563	



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International application No.
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Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
 - This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
 - international search (under Rules 12.3 and 23.1(b))
 - publication of the international application (under Rule 12.4)
 - international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

Description, Pages

1-6, 10-12	as originally filed
7-9	filed with telefax on 14.02.2006

Claims, Numbers

1-24	received on 14.09.2005 with letter of 31.08.2005
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Drawings, Sheets

1/5-5/5	as originally filed
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a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. The amendments have resulted in the cancellation of:
 - the description, pages
 - the claims, Nos.
 - the drawings, sheets/figs
 - the sequence listing (*specify*):
 - any table(s) related to sequence listing (*specify*):
4. This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
 - the description, pages
 - the claims, Nos.
 - the drawings, sheets/figs
 - the sequence listing (*specify*):
 - any table(s) related to sequence listing (*specify*):

* If item 4 applies, some or all of these sheets may be marked "superseded."

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Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-24
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-24
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-24
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VII Certain defects in the international application

The following defects in the form or contents of the international application have been noted:

see separate sheet

Box No. VIII Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

see separate sheet

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Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Reference is made to the following documents:

- D1: GB-A-1 080 217 (MAXIME JEAN ROUVIN; PAUL FERNAND ROUVIN; PHILIPPE EDMOND ROUVIN) 23 August 1967 (1967-08-23)
D2: US-A-2 549 686 (HJULIAN JULIUS A) 17 April 1951 (1951-04-17)
D3: US-A-3 966 546 (BRAATEN ET AL) 29 June 1976 (1976-06-29)

- 2.1 The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and discloses (the references in parentheses applying to this document) a process for the extrusion of a cementitious green body from a paste or suspension of cementitious particulate material in a liquid, wherein the process includes the steps of:

- (a) supplying the cementitious paste or suspension at a low pressure to, and thereby filling at the low pressure, an extrusion chamber of an extruder having a piston operable in said chamber (figure 6; page 2, column 2, lines 80-97);
(b) applying by means of the piston a high pressure to the paste or suspension on completion of step (a) whereby the paste or suspension is forced from the extrusion chamber and through a moulding spaced with a dewatering section defined by at least partially liquid-permeable walls (figure 6; page 2, column 2, lines 92-114); and
(c) removing a substantial part of the liquid by the high pressure applied in step (b) establishing a pressure differential across at least parts of said wall that are permeable to said liquid to form and maintain a non-flowable shaped body of said particulate material to bring dewatered paste to a final shape for the green body (page 2, column 2, lines 115-126); and
wherein the extrusion chamber has substantially the same principle cross sectional geometry or form as the final product and the piston by which the suspension is pressurised has the same cross sectional geometry as the final product for fitting into the extrusion chamber (figures 5-7).

The subject-matter of claim 1 therefore differs from this known method in the steps of:

- (a) supplying the cementitious paste or suspension at a low pressure of less

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- than 20 bar,
- (b) applying by means of the piston a high pressure of at least 80 bar to the paste or suspension on completion of step (a).

The subject-matter of claim 1 is therefore new in the sense of Article 33(2) PCT.

- 2.2 The objective problem underlying claim 1 may therefore be regarded as how to overcome internal de-watering of the suspension at locations other than the de-watering section of the extruder (description page 5, lines 23-29).

The solution to this problem proposed in claim 1 of the present application is neither known, nor suggested by the available prior art concerning piston driven extrusion machines. The subject-matter of claim 1 is therefore considered as involving an inventive step (Article 33(3) PCT).

- 2.3 The document D1 is regarded as being the closest prior art to the subject-matter of claim 13, and discloses (the references in parentheses applying to this document) an apparatus for use in the extrusion of a cementitious green body from a cementitious paste or suspension of particulate material in a liquid, wherein the apparatus includes:

- an extrusion chamber (20);
- a piston (17) for pressurizing the extrusion chamber;
- a moulding space with a dewatering section defined by at least partially liquid-permeable walls (25);
- means for supplying the paste or suspension to and filling the extrusion chamber at a low pressure (22); and
- means for moving the piston (15,16) for applying a high pressure to the paste or suspension in the extrusion chamber (20) and forcing the paste or suspension from the extrusion chamber (20) and through the moulding space, and thereby remove a substantial part of the liquid by establishing a pressure differential across at least parts of said wall permeable to said liquid to form and maintain a non-flowable shaped body of said particulate material and bring the dewatered paste or suspension to a final shape for the green body (page 2, column 2, lines 80-126); and wherein the extrusion chamber has the same principle cross sectional geometry or form as the final product and wherein the piston has the same cross sectional geometry as the final product for fitting into the extrusion chamber (figures 5-7).

The subject-matter of claim 13 therefore differs from this known apparatus by the means for supplying the paste or suspension to and filling the extrusion chamber at a low pressure of less than 20 bar; and by the means for moving the piston for applying a high pressure of at least 80 bar to the paste or suspension in the extrusion chamber.

The subject-matter of claim 13 is therefore new in the sense of Article 33(2) PCT.

- 2.4 The objective problem underlying claim 13 may therefore also be regarded as how to overcome internal de-watering of the suspension at locations other than the de-watering section of the extruder (description page 5, lines 23-29).

The solution to this problem proposed in claim 13 of the present application is neither known, nor suggested by the available prior art concerning piston driven extrusion machines. The subject-matter of claim 13 is therefore considered as involving an inventive step (Article 33(3) PCT).

3. Claims 2-12, 14-24 respectively are dependent on claims 1 and 13 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.
4. The subject-matter of claims 1-24 is considered as susceptible of industrial application (Article 33(4) PCT).

Re Item VII

Certain defects in the international application

1. Contrary to the requirements of Rule 5.1(a)(ii) PCT, the relevant background art disclosed in the documents D1-D3 is not mentioned in the description, nor are these documents identified therein.
2. The features of the claims are not provided with reference signs placed in parentheses (Rule 6.2(b) PCT).

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Re Item VIII

Certain observations on the international application

1. The relative terms "substantially the same principle cross sectional geometry", "substantially only" and "close to the end" used in claims **1,2 and 17** have no well-recognised meaning and leave the reader in doubt as to the meaning of the technical features to which they refer, thereby rendering the definition of the subject-matter of said claim unclear, Article 6 PCT and the PCT Guidelines 5.34.
2. Claims **8 and 20** do not meet the requirements of Article 6 PCT in that the matter for which protection is sought is not clearly defined. The following functional statements "on completion of ... sweeps across the leading face of the piston" do not enable the skilled person to determine the exact inclination of the piston head.
3. The vague and imprecise statement in the description on page 12, lines 14-19 implies that the subject-matter for which protection is sought may be different to that defined by the claims, thereby resulting in lack of clarity (Article 6 PCT) when used to interpret them.

because the de-watering at the de-watering section works according to the same principles as at the dead-spots.

Brief Summary of the Invention

The present invention seeks to provide a process and apparatus enabling green body extrusion by dewatering a paste or suspension of cementitious particulate material, which facilitates operation under high pressure and thereby enables practical production rates. The process is called in-line, dewatering extrusion and the corresponding apparatus is called an in-line dewatering extruder.

We have found that in de-watering extrusion of a cementitious suspension to produce a green body extrusion, there are some fundamental relationships, which govern suspension stability and the risk of de-watering/separation. We have found that the rate of de-watering in a given situation is approximately proportional to the pressure differential.

According to the present invention, there is provided a process for the extrusion of a cementitious green body from a paste or suspension of cementitious particulate material in a liquid, wherein the process includes the steps of:

(a) supplying the cementitious paste or suspension at a low pressure of less than 20 bar to, and thereby filling at the low pressure, an extrusion chamber of an extruder having a piston operable in said chamber;

(b) applying by means of the piston a high pressure of at least 80 bar to the paste or suspension on completion of step (a) whereby the paste or suspension is forced from the extrusion chamber and through a moulding spaced with a dewatering section defined by at least partially liquid-permeable walls; and

(c) removing a substantial part of the liquid by the high pressure applied in step (b) establishing a pressure differential across at least parts of said wall that are permeable to said liquid to form and maintain a non-flowable shaped body of said particulate material to bring dewatered paste to a final shape for the green body; and

wherein the extrusion chamber has substantially the same principle cross-sectional geometry or form as the final product and the piston by which the suspension is pressurised has the same cross-sectional geometry as the final product for fitting into the extrusion chamber.

In the process of the invention, the concept of a continuous process is abandoned and the low pressure filling of the extrusion chamber is separated from the high pressure extrusion of the suspension. Extrusion pressure sufficient to establish industrial scale extrusion rates is thereby facilitated. Filling of the extrusion chamber is done at low pressure below 20 bar, preferably below 10 bar.

The application of a substantially higher pressure to force the suspension from the extrusion chamber and into the moulding space is done at a pressure of at least 80 bar, such as from 80 to 240 bar, more preferably from 100 to 180 bar and most preferably about 150 bar.

5 The extrusion chamber has the same principle cross-sectional geometry or form as the final product and it most preferably is pressurized using a piston with the same cross-sectional geometry as the final product (and fitting into the extrusion chamber). In the process, the suspension may experience only cross-sectional reductions in its flow through the extrusion chamber towards the de-watering sections, enabling the
10 formation of dead spots to be prevented. In this case, the cross-sectional area of the extrusion chamber is larger than the cross-section of the extruded body. The cross-section reduction may be between 1:2 and 1:10, preferably between 1:3 and 1:6.

15 In order to further minimise the risk of pre-consolidation, an inlet port or each inlet port to the extrusion chamber is placed at or close to the end of the extrusion chamber through which the suspension is forced during the extrusion of step (b). Thus, the inlet port or each inlet port may be located where the piston head is positioned on completion of an extrusion stroke and emptying of the extrusion chamber.

20 Further, the piston head may have a leading face, by which high pressure is applied to the suspension in step (b), which is inclined with respect to the line of movement of the piston. The inclination preferably is such that, on completion of a full extrusion stroke of the piston head, a flow of suspension for filling the extrusion chamber in step (a) for the next stroke, or part of a stroke, cleans the leading face of the piston. Also, the filling of the extrusion chamber in each step (a) can cause or assist in movement of the piston to its retracted position.

25 In a preferred form, the process of the invention (in-line de-watering extrusion) includes the steps of:

- (a) supplying the suspension to and substantially filling an extrusion chamber at a relatively low pressure below 20 bar, preferably below 10 bar;
- (b) applying a substantially higher pressure in excess of 80 bar, such as from 80 to 30 240 bar, to the suspension on completion of step (a) whereby the suspension is forced through a moulding spaced with at least partially liquid-permeable walls; and
- (c) removing a substantial part of the liquid by establishing a pressure differential across at least parts of said wall that are permeable to said liquid to form a 35 non-flowable shaped body of said particulate material;
wherein the body has a reduced cross-section relative to the extrusion chamber of between 1:2 to 1:10, preferably between 1:3 to 1:6.

The invention also provides an apparatus for use in the extrusion of a cementitious green body from a cementitious paste or suspension of particulate material in a liquid, wherein the apparatus includes:

- an extrusion chamber;
- 5 - a piston for pressurizing the extrusion chamber;
- a moulding space with a dewatering section defined by at least partially liquid-permeable walls;
- means for supplying the paste or suspension to and filling the extrusion chamber at a low pressure of less than 20 bar; and
- 10 - means for moving the piston for applying a high pressure of at least 80 bar to the paste or suspension in the extrusion chamber and forcing the paste or suspension from the extrusion chamber and through the moulding space, and thereby remove a substantial part of the liquid by establishing a pressure differential across at least parts of said wall permeable to said liquid to form and maintain a non-flowable shaped body of said particulate material and bring the dewatered paste or suspension to a final shape for the green body; and
- 15 - wherein the extrusion chamber has the same principle cross-sectional geometry or form as the final product and wherein the piston has the same cross-sectional geometry as the final product for fitting into the extrusion chamber.

20 In order that the invention may more readily be understood, description is directed to the accompanying drawings, in which:

Figure 1 is a vertical sectional view through apparatus according to the present invention; and

Figures 2 to 5 correspond to Figure 1, but illustrate the apparatus in respective 25 conditions in the course of an extrusion cycle.

Figures 2 to 5 show the same components of apparatus 10 of Figure 1. Thus, the same reference numeral denotes the same component in each of Figures 1 to 5.

The apparatus 10 is of a form suitable for producing a cylindrical green body of a cementitious suspension, suitable for curing to produce an extruded concrete pipe.

30 The apparatus 10 thus has a circular form in cross-section, although other arrangements are possible for the extrusion of products of other cross-sectional shape.

With reference to Figure 1, the apparatus 10 has an outer cylindrical part or housing 12 within which an inner part or mandrel 14 is disposed. An extrusion chamber 16 of annular form is defined within housing 12, around mandrel 14. An 35 annular piston 18 is slidable in housing 12, along mandrel 14. The means by which mandrel 14 is mounted in housing 12 has not been shown, for simplicity of illustration while, except as detailed later herein, means for longitudinally moving piston 18 has similarly been

CLAIMS

1. A process for the extrusion of a cementitious green body from a paste or suspension of cementitious particulate material in a liquid, wherein the process includes the steps of:

- 5 (a) supplying the cementitious paste or suspension at a low pressure of less than 20 bar to, and thereby filling at the low pressure, an extrusion chamber of an extruder having a piston operable in said chamber ;
(b) applying by means of the piston a high pressure of at least 80 bar to the paste or suspension on completion of step (a) whereby the paste or
10 suspension is forced from the extrusion chamber and through a moulding spaced with a dewatering section defined by at least partially liquid-permeable walls; and
(c) removing a substantial part of the liquid by the high pressure applied in step (b) establishing a pressure differential across at least parts of said
15 wall that are permeable to said liquid to form and maintain a non-flowable shaped body of said particulate material to bring dewatered paste to a final shape for the green body; and

wherein the extrusion chamber has substantially the same principle cross sectional geometry or form as the final product and the piston by which the

20 suspension is pressurised has the same cross sectional geometry as the final product for fitting into the extrusion chamber.

2. The process of claim 1, wherein the paste or suspension experiences substantially only cross sectional reductions in its flow through the extrusion chamber towards the de-watering section; and wherein the cross sectional area of the extrusion chamber is larger than the cross-section of the extruded body.

3. The process of claim 2, wherein the paste or suspension undergoes a cross section reduction of between 1:2 and 1:10.

4. The process of claim 3, wherein the reduction is from 1:3 and 1:6

5. The process of any one of claims 1 to 4, wherein supplying the paste or
30 suspension in step (a) is through at least one inlet port to the extrusion chamber placed at or close to the end of the extrusion chamber through which the paste or suspension is forced during the extrusion of step (b).

6. The process of any one of claims 1 to 5, wherein supplying the paste or suspension in step (a) is through at least one inlet port located where the piston

head is positioned on completion of an extrusion stroke and emptying of the extrusion chamber.

7. The process of claim 6, wherein high pressure is applied to the paste or suspension in step (b) by a leading face of the piston head which is inclined with respect to the line of movement of the piston.

8. The process of claim 7, wherein the inclination is such that, on completion of an extrusion stroke, a flow of paste or suspension for filling the extrusion chamber in step (a) for a next stroke, or part of a stroke, sweeps across the leading face of the piston.

10 9. The process of claim 8, wherein filling of the extrusion chamber in each step (a) causes or assists in movement of the piston to a retracted position.

10. The process of any one of claims 1 to 9, wherein the low pressure at which step (a) is conducted is less than 10 bar.

11. The process of any one of claims 1 to 10, wherein the high pressure applied to the paste or suspension in step (b) is from 80 to 240 bar.

12. The process of claim 11, wherein the high pressure applied is from 100 to 180 bar.

13. An apparatus for use in the extrusion of a cementitious green body from a cementitious paste or suspension of particulate material in a liquid, wherein
20 the apparatus includes:

- an extrusion chamber;
- a piston for pressurizing the extrusion chamber;
- a moulding space with a dewatering section defined by at least partially liquid-permeable walls;
- 25 - means for supplying the paste or suspension to and filling the extrusion chamber at a low pressure of less than 20 bar; and
- means for moving the piston for applying a high pressure of at least 80 bar to the paste or suspension in the extrusion chamber and forcing the paste or suspension from the extrusion chamber and through the moulding space, and thereby remove a substantial part of the liquid by establishing a pressure differential across at least parts of said wall permeable to said liquid to form and maintain a non-flowable shaped body of said particulate material and bring the dewatered paste or suspension to a final shape for the green body; and

wherein the extrusion chamber has the same principle cross sectional geometry or form as the final product and wherein the piston has the same cross sectional geometry as the final product for fitting into the extrusion chamber.

14. The apparatus of claim 13, wherein the extrusion chamber is operable to cause the paste or suspension to experience only cross sectional reductions in flow through the extrusion chamber towards the de-watering section, and wherein the cross sectional area of the extrusion chamber is larger than the cross-section of the extruded body.
5
15. The apparatus of claim 14, wherein the extrusion chamber is operable to cause the paste or suspension to undergo a cross section reduction of between 1:2 and 1:10.
10
16. The apparatus of claim 15, wherein the reduction is from 1:3 and 1:6.
17. The apparatus of any one of claims 13 to 16, wherein the means for supplying the paste or suspension includes at least one inlet port to the extrusion chamber placed at or close to the end of the extrusion chamber through which the suspension is forced by said means for applying high pressure.
15
18. The apparatus of any one of claims 13 to 17, wherein the means for supplying the paste or suspension includes at least one inlet port located where the piston head is positioned on completion of an extrusion stroke and emptying of the extrusion chamber.
20
19. The apparatus of claim 18, wherein the means for applying a high pressure is applied to the paste or suspension in step (b) by a leading face of the piston head which is inclined with respect to the line of movement of the piston.
25
20. The apparatus of claim 19, wherein the inclination is such that, on completion of an extrusion stroke, a flow of paste or suspension for filling the extrusion chamber for a next stroke, or part of a stroke, sweeps across the leading face of the piston.
- 30 21. The apparatus of claim 20, wherein the means for supplying the paste or suspension is adjusted to cause or assist in movement of the piston to a retracted position.

22. The apparatus of any one of claims 13 to 21, wherein the supplying means is operable to supply the paste or suspension at a pressure less than 10 bar.
23. The apparatus of any one of claims 13 to 22, wherein the pressure applying means is operable to force the paste or suspension at a pressure of from 80 to 240.
24. The apparatus of claim 23, wherein the pressure applying means is operable to force the paste or suspension at a pressure of from 100 to 180 bar.